

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re the Application of: Ronan Dif et al.	Group Art Unit: 1742  Examiner: J.A. Morillo
Serial No.: 10/614,888	
Filed: July 9, 2003	
For:   ALCUMG ALLOYS WITH HIGH DAMAGE TOLERANCE SUITABLE FOR USE AS STRUCTURAL MEMBERS IN AIRCRAFTS	

**DECLARATION UNDER 37 CFR 1.132**

Honorable Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Dear Sir:

I, Bernard Bes do hereby declare as follows:

1.       I have worked in the aluminum industry for over 25 years specializing in the optimization of aluminum alloy compositions and processing.

I am a named inventor the above-identified patent application ("the present application").

I understand that in an Office Action dated July 17, 2006, the USPTO has rejected the present application based on US Patent No 6,562,154 (Rioja). I am familiar with this Rioja reference.

2.       The present application is directed to products with high strength and very high damage tolerance properties that are suitable for lower wing skin structures. The products concerned are generally at least 12 mm in thickness and these products are particularly useful for applications such as lower wing plates.

3. I surprisingly observed that for a 2XXX alloy without Mn, a very small addition of scandium, together with about 0.08-0.20% zirconium and 3.8-4.2 copper has a remarkably strong effect on microstructure and properties. The effect was completely unexpected and it was observed for a Sc content of about 300 ppm. Under my direction and/or control the effect on microstructure and properties of adding about 300 ppm Sc, 3.8-4.2 Cu, and about 0.08-0.20% Zr was analyzed and the results are shown in Figures 1 and 2 provided below.

In the T39 temper, Figure 1 below illustrates the compromise between strength (UTS L-direction, from Table 4) and toughness (K<sub>ap</sub> L-T, for CT specimen W=1.6" from Table 6) for the 5 alloys studied. Figure 1 clearly shows that for a similar strength, the use of the Sc and Zr in a 2XXX alloy without Mn provides a gain in toughness of more than 10% and for a similar toughness, a gain in strength of more than 6%. This was surprising and completely unexpected since one of skill in the art would have not thought that such a small amount of Sc taken with Cu from 3.8-4.2 and Zr from 0.08-0.20 would have provided such an unexpected result. The results I noticed were critical with regard to the amount of Sc, Cu and Zr employed.

Similarly, in the T89 temper, Figure 2 below illustrates the compromise between strength (UTS L-direction, from Table 9) and toughness (K<sub>ap</sub> L-T, for CT specimen W=1.6" from Table 10) for the 5 alloys studied. Again, it clearly shows that for a similar strength, the gain in toughness was more than 25% and for a similar toughness the gain in strength was more than 4%. As with the data reported in Figure 1, the results of Figure 2 were surprising and completely unexpected since one of skill in the art would have not thought that such a small amount of Sc taken with 3.8-4.2 Cu and Zr from 0.08-0.20 would have provided such an unexpected result. The results I noticed were critical with regard to the amount of Sc, Cu and Zr we employed.

4. Since the present application was filed in 2003, many new results have confirmed this effect. Industrial trials have confirmed several times that a better compromise between toughness and strength was obtained by using about 300 ppm Sc, 3.8-4.2 Cu,

and from 0.08-2.0% Zr in a 2XXX alloy without Mn. In particular, under my direction and/or or control, R-curves in the T39 temper for M(T) specimen W=16" wide test samples were obtained and confirmed the improvement in toughness.

5. Since Rioja only reports R curves for M(T) specimen W=16" wide test samples with T3 temper (Figure 13 of Rioja), under my direction and/or control, R curve data obtained for similar test samples in T351 temper was also prepared as well. Surprisingly, example 770310 of Rioja, which differs from the present invention by the Sc content and the copper content, exhibits a compromise between strength and toughness much less favorable than an alloy having about 300 ppm Sc, 3.8-4.2 Cu and 0.08-0.20 Zr.

Rioja is directed to fuselage sheet and provides  $K_{app}$  results for M(T) W=16" test samples. It was not possible to directly compare these results with toughness properties from the present application ( $K_{app}$  results are for CT specimen W=1.6"), under my direction and/or control, further experiments were undertaken for M(T) W = 16" test samples. Namely, an alloy from the present invention (reference S) with the composition provided in Table 1 was transformed to plates with a thickness of 30 mm to a T351 (S-T351) and T39 (S-T39) temper.

Table 1. Composition (wt.%) of alloy S.

Alloy	Si	Fe	Cu	Mn	Mg	Zn	Ti	Zr	Sc
S	<0.06	<0.04	3.95	<0.05	1.25	0.008	0.008	0.109	0.028

Fracture toughness values were obtained on 16 by 44 inch center notch fracture toughness specimens (M(T)) in accordance to ASTM E561 for sample thickness B = 0.25" (2a<sub>0</sub> = 0.25").

R-curve data obtained is presented in Figure 3. Rioja results for sheet 770308 (Zr) and 770310 (Zr + Sc), as read from Figure 13 of Rioja, are also included.

Two remaining differences between products of the present application and Rioja can be noted. First, Rioja employed a test sample thickness of 0.15" while 0.25" was employed

for the present invention. And second, the present application employs T39 and T351 tempers while Rioja employs T3 since stretching is not mentioned for the process of Rioja (see column 8). Regarding the first difference, as the test sample thickness difference is small, it is my opinion as one of skill in the art, that this small difference would not significantly affect the R-curve in any meaningful way in regard to the comparison. Regarding the second difference, the effect of 2% stretching can be evaluated from the difference between T351 and T39 tempers.

As far as damage tolerance properties are concerned, the development of an R-Curve is a widely recognized method to characterize fracture toughness properties. It is a standard evaluation for one of skill in the art. The R-curve represents the evolution of the effective stress intensity factor for crack growth as a function of effective crack extension, under increasing monotonic loading. It enables the determination of the critical load for unstable fracture for any configuration relevant to cracked aircraft structures. An R-curve allows a comparison of fracture toughness in a way which is relevant to design : when the R-curve is higher in a given value, the allowable stress for design will be higher.  $K_c$  is a particular point of the R-curve that corresponds to the maximum load of the considered test. In Figure 3, the  $K_c$  point has been identified for each sample.  $K_{app}$  is very significant in this particular case since  $K_{app}$  does not include variations on effective crack length at maximum loading.

7. From a comparison of Figure 3 between Rioja and samples according to the present application, it clearly appears to me as one of skill in the art, that the samples of the present application exhibit a much higher toughness (around 20% higher) than Rioja 770310. It is also readily apparent to me from Figure 3 that here, the  $K_c$  values cannot be compared because they were obtained for very different effective crack lengths. However, the  $K_{app}$  values can be compared, as shown below in Table 2 and Figure 4 (Rioja results for sheet 770308 (Zr) and 770310 (Zr + Sc), as read from Figure 15 of Rioja, are also included). Note that the S alloy with a T3 temper has been estimated from T351 and T39 results and is shown in italics.

Table 2

	Total Cold work after quenching	Longitudinal TYS (ksi)	$K_{app}$ ksi $\sqrt{in}$ L-T
S-T351	2%	55.0	113
S-T39	12%	64.5	124
<i>S-T3</i>	<i>0%</i>	<i>53.1*</i>	<i>111*</i>
Rioja sample 310 (Figure 15)		46	95
Rioja sample 308 (Figure 15)		49	97

\* estimate

Extrapolating from 2% to 0% cold work is a rough estimate, however it is my current opinion that this estimation does not significantly affect the results or any conclusions made herein.

The results demonstrate that the tensile yield strength of a product according to the present application having the stated Sc, Zr and Cu quantities is about 15% higher than sample 310 of Rioja, while  $K_{app}$  (W=16") is about 17% higher for the present application samples. It is my opinion as one of skill in the art, that the above results show that the plates having a thickness of at least about 12 mm and formed of an alloy having Sc, Cu and Zr as identified above, provides surprising and unexpected results as compared with Rioja and the values and compositions tested also demonstrate the criticality of these aspects

8. While not to be bound to any specific theory, as one of skill in the art, it is my present opinion that it is possible that the data I observed may be due to an interaction between copper and scandium. The difference in scandium and copper composition between the present invention and Rioja sample 770310 may explain why such a significant improvement with relatively limited composition differences was observed.

9. It should also be noted that no guidance is provided by Rioja to add scandium in the range proposed by the present invention. To the contrary, the comparison between sample 770308 and 770310 from Rioja (Figure 15) does not encourage to add scandium as TYS significantly decreases from 49 ksi to 46 ksi,  $K_{app}$  is roughly the same and  $K_c$  does increase, but as mentioned earlier,  $K_c$  values obtained for very different effective crack length cannot be directly compared. Starting from Rioja, one skilled in the art would not have been directed to increase the Sc content. Even if one of skill in the art had followed Rioja's teaching regarding the effect of scandium to attain unrecrystallized structures, that person would not have been guided to a specific value as Rioja teaches up to about 1%. It is also possible that the Cu-Sc interaction mentioned above prevented the Sc containing alloy of Rioja to obtain an improved strength-toughness compromise.

10. I further declare that all statements made by me herein are true and all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and may jeopardize the validity of the application or any patent issued thereon.

15<sup>th</sup> of December 2006  
Date



---

Bernard Bes

Figure 1. Strength / toughness compromise in the T39 temper.

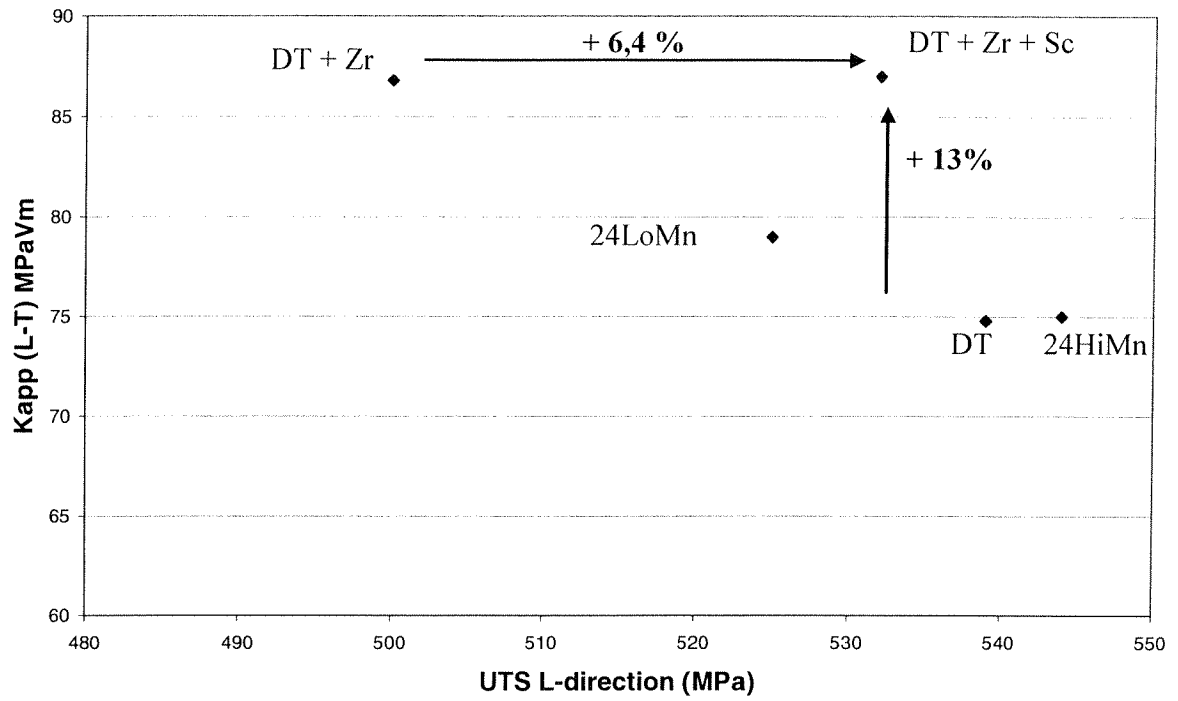


Figure 2. Strength / toughness compromise in the T89 temper.

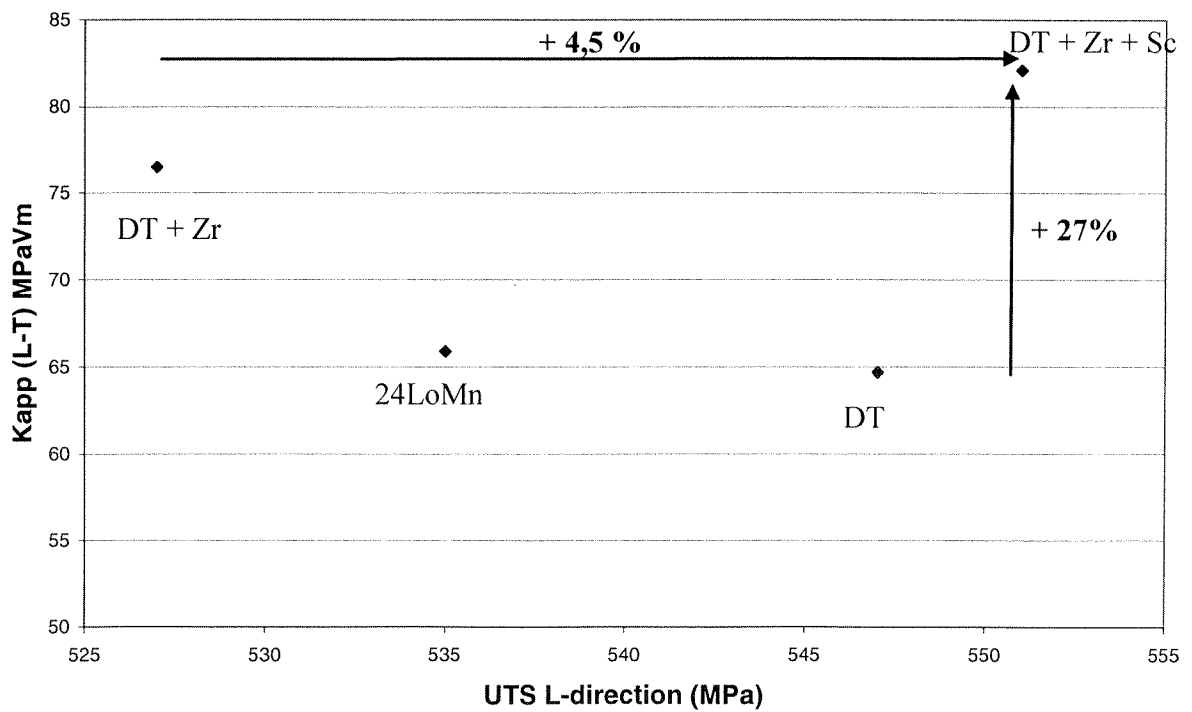


Figure 3

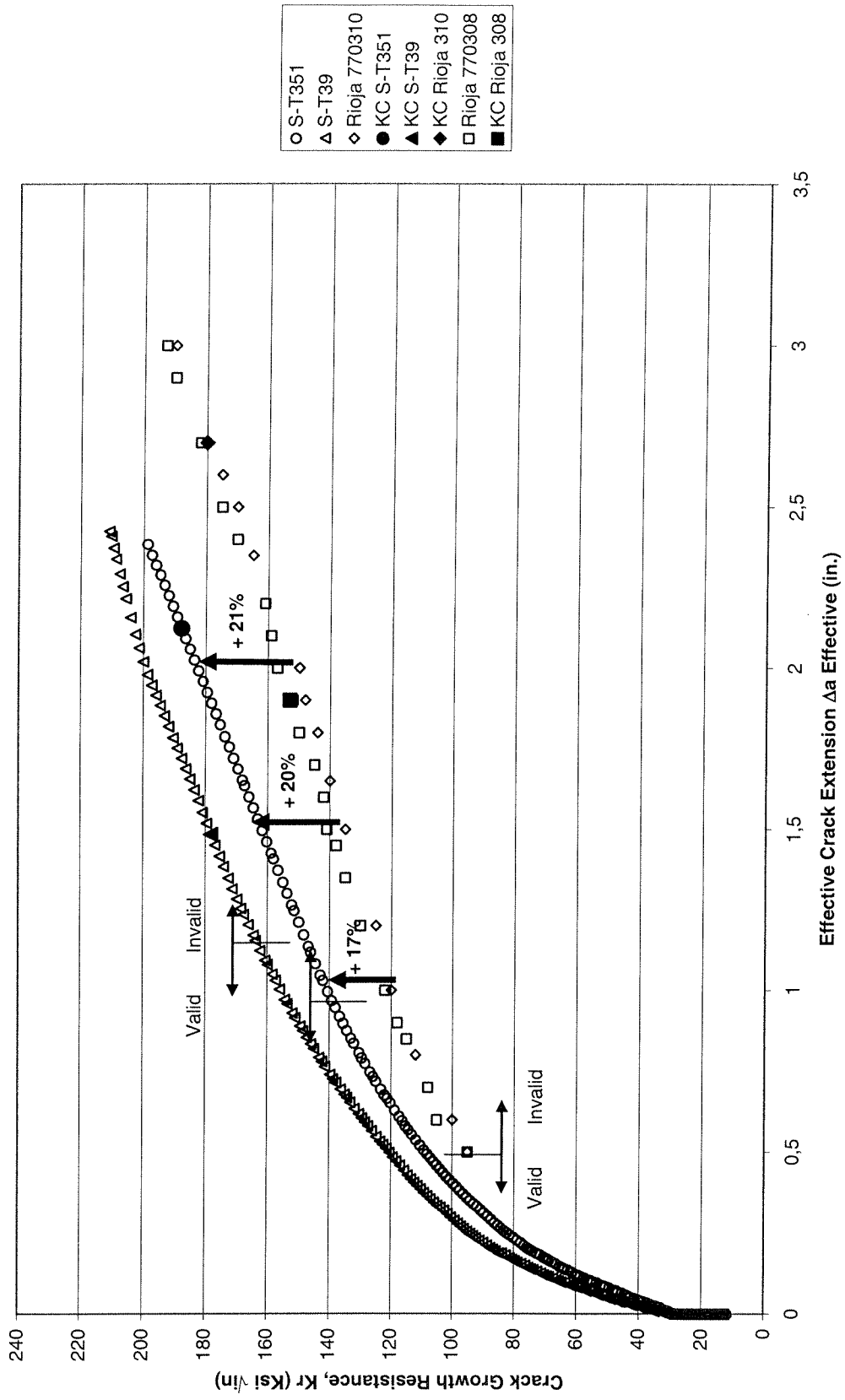




Figure 4

